Renewable and Sustainable Energy Reviews 18 (2013) 87–94

Contents lists available at SciVerse ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Natural gas consumption and economic growth in Pakistan

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ARTICLE INFO

Article history:
Received 24 July 2012
Received in revised form
17 September 2012
Accepted 23 September 2012
Available online 3 November 2012

Keywords:
Natural gas consumption
Economic growth
Pakistan

ABSTRACT

Natural gas is a dominant fuel in Pakistan. It offers the cheapest and a cleaner alternative source of energy. This paper examines the relationship of natural gas consumption and economic growth in Pakistan. We include capital, labor and exports in the model with multivariate framework. The ARDL bounds testing approach to cointegration and innovative accounting approach are employed to investigate the dynamic causality relationships among the variables. We find the existence of long-run relationship among the variables. Natural gas consumption, capital, labor and exports are positively affecting economic growth in Pakistan. Furthermore, we support the natural gas consumption-led-growth hypothesis and suggest that natural gas conservation policies may retard economic growth.

Contents

1. Introduction

Natural gas is an important source of electricity generation. In order to meet the Kyoto targets in reducing CO_2 emissions, many countries are exploring policy options to encourage the use of natural gas as an alternative source (Apergis and Payne [1]). Natural gas becomes an attractive option because it is more efficient, provides a better operational flexibility, reduces CO_2 emission and lowers capital costs. EIA reported that world natural gas consumption as a percentage of total energy is around 21% and 23% in 1990 and 2007, respectively. Likewise, the total natural gas consumption is expected to grow at 18% annually between 2007 and 2035.

Developing countries such as Pakistan are not likely to attract investment in establishing expensive fuel strategies[1] and thus natural gas becomes the alternative. Natural gas is a dominant fuel in Pakistan accounting for 47% of primary energy demand in 2007. Since 2000, natural gas and petroleum are the main sources of energy in Pakistan consist of 50% and 29% of total energy consumption, respectively (Pakistan Energy Yearbook [2]). Nevertheless, the consumption of petroleum is decreasing due to the hike of petroleum prices and vehicles are converted to using natural gas. Furthermore, the government also encourages of using local compressed gas and liquefied petroleum gas in the

[1] Pakistan had development plan for hydropower but it was discontinued due to difficulties in acquiring foreign investment (EIA [4]). Pakistan's nuclear power contribution to total energy production is small by supplying only 2.34% of the country's electricity generation (World Nuclear Association, http://www.world-nuclear.org/info/inf108.html).

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http://dx.doi.org/10.1016/j.rser.2012.09.029

transportation and power sectors. These two sectors account for nearly 51% and 40% of the total gas consumption, respectively (GoP [3]). Natural gas also offers the cheapest and a cleaner alternative source of energy. Therefore, it is important and timely to investigate the linkage of natural gas consumption and economic growth in case of Pakistan.

Existing empirical studies on natural gas consumption and economic growth is limited and lack of consensus on the findings. To our best of knowledge, in the case of Pakistan, only four studies (Aqeel and Butt [5], Siddiqui [6], Zahid [7], Khan and Ahmed, [8]) are available with mixed evidences. However, the analysis is limited by the model specification issues and appropriate estimation methods. Lütkepohl [9] indicated that omitted of relevant variables in the estimation contributes to bias and inconsistent results. Inclusion of control variables such as capital and labor in a multivariate model helps to provide more reliable result (Loizides and Vamvoukas [10]).

The direction of causality is very important and has major implications for energy policy. If there is a unidirectional causality running from natural gas consumption to economic growth, reducing natural gas consumption could lead to a fall in economic growth. In contrast, if there is a unidirectional causality running from economic growth to natural gas consumption, it could imply that policies aim to reducing natural gas consumption may be implemented with little or no adverse effect on economic growth. On the other hand, if there is no causality between the variables then natural gas conservation policies may not affect economic growth. In contrast, if there is bidirectional causality then natural gas consumption can stimulate economic growth and in turn economic growth may induce more demand for natural gas.

This paper intends to offer a more robust model specification to investigate the relationship between economic growth and natural gas consumption in Pakistan. We include capital, labor and exports in the model with multivariate framework. The role of exports in boosting economic growth is well documented. Exports increase total factor productivity because of their impact on economies of scale and other externalities such as technology transfer, improving workers and managerial skills and increasing production capacity. It also allows for a better utilization of resources and does not discriminate the domestic market (Grossman and Helpman [11], Rivera-Batiz and Romer [12]). It is expected that by including exports in the analysis, one can get a better picture of the relationship between natural gas consumption and economic growth.

In addition, the use of recent estimation techniques such as the auto regressive distributed lag (ARDL) bounds testing, error correction model (ECM) and Innovative Accounting Approach (IAA) allow us to ensure the robustness of the results. Chandran et al. [13] indicated that country specific study allows one to take into account the institutional, structural and policy reform more specifically. Indeed, it offers more room of discussing policy implications for the country under the study.

2. Literature review

A number of studies have examined the causal relationship between natural gas consumption and economic growth in different countries using various approaches. For example, Yu and Choi [14] for UK, US and Poland; Yang [15] for Taiwan, Aqeel and Butt [5]) and Siddiqui [6] for Pakistan, Fatai et al. [16] for New Zealand and Australia, Lee and Chang [17] for Taiwan, Ewing et al. [18] for US, Zamani [19] and Amadeh et al. [20] for Iran, Hu and Lin [21] and Sari et al. [22] for US, Reynolds and Kolodziej [23] for Soviet Union, Zahid [7] for five South Asian countries, Adeniran [24] and Clement [25] for Nigeria. Different from the single and multi countries studies above, Apergis and Payne [1] did a panel analysis for 67 countries. Recently, Kum et al. [26] investigated the relationship between natural gas consumption and economic growth for G7 countries. Table 1a summarizes the main information and findings of these empirical literatures.

The review of literature highlights three important points. First, the results are not unanimous and lack of country specific. Second, the estimation methods are less appropriate in some studies especially those using bivariate model is subjected to omitted variable biasness. Third, the sample periods of study are not current without taking into account the current development. For instance, the global economic crisis and the recent development in climate change agenda have drastically changed the fuel mix policy. Therefore, without the inclusion of this time period, results of the previous studies might be outdated.

Empirical studies on the causality between natural gas consumption and economic growth in Pakistan is limited. Aqeel and Butt [5] examined the causality between three energy consumptions (i.e., petroleum, electricity and natural gas) and economic growth. They found absence of cointegration and causality between natural gas consumption and economic growth. Siddiqui [6] and Zahid [7] also cannot find any causal relationship between natural gas consumption and economic growth. On the other hand, Khan and Ahmed [8] found that natural gas consumption Granger causes economic growth for the period of 1972–2007.

We note that these four empirical studies are based on bivariate model. Therefore, their results are biased and inconsistent. Literature noted that economic growth is influenced by capital and labour. The above four studies ignored the role of capital and labour in the production function. This shortcoming can be overcomed by including capital and labour in the estimation to make the result more reliable (Loizides and Vamvoukas [10], Odhiambo [27], Shahbaz et al. [56]).

3. Data and methodology

Recent empirical studies such as Stern [34], Ghali and El-Sakka [35], Beaudreau [36], Sari and Soytas [37], Lee and Chang [17], Yuan et al. [38], Wolde-Rufael [39] and Shahbaz and Lean [40] used the production function framework to examine the causal relationship between energy consumption and economic growth. Following the existing literature, conventional neo-classical production model is used where natural gas consumption, capital, labor and exports are treated as separate production factors as below:

$$Y_t = f(GC_t, K_t, EM_t, EXP_t,) \tag{1}$$

where Y_t is the real GDP per capita, GC_t is natural gas consumption per capita, K_t is real capital use per capita, EM_t is the employed labor per capita and EXP_t is real exports per capita. This study covers the sample period of 1972–2010. The data on real GDP, natural gas consumption, real capital, employment and real exports are obtained from economic survey of Pakistan (various issues)[2]. The log linear specification of Eq. (1) is as follows:

$$\ln Y_t = \alpha_1 + \alpha_{GC} \ln GC_t + \alpha_K \ln K_t + \alpha_{EM} \ln EM_t + \alpha_{EXP} \ln EXP_t + \varepsilon_t \tag{2}$$

The elasticity of natural gas consumption, real capital, labor and real exports are indicated by α_{GC}, α_K, α_{EM} and α_{EXP}, respectively.

3.1. The ARDL bounds testing approach to cointegration

We employ the ARDL bounds testing approach to cointegration developed by Pesaran et al. [41] to explore the existence of

[2] CPI is used to convert the series into real term.

Table 1
Summary of previous studies.

Authors	Countries	Sample period	Methodology	Variables	Cointegration	Causality
Single-country studies						
Yang [15]	Taiwan	1954–1997	GC	Real GDP, Natural Gas Consumption	No	$G\rightarrow Y$
Aqeel and Butt [5]	Pakistan	1955–1996	GC by Hsiao [28]	Real GDP, Natural Gas Consumption	No	$Y\times G$
Siddiqui [6]	Pakistan	1970–2003	ADL, GC by Hsiao [28]	Real GDP, Natural Gas Consumption	N. A	$Y\times G$
Lee and Chang [17]	Taiwan	1954–2003	JML, WE,	Real GDP, Natural Gas Consumption	Yes	$G\rightarrow Y$
Ewing et al. [18]	US	2001–2005	GFEVD	Industrial Production, Natural Gas Consumption	N. A	$G\rightarrow Y$
Zamani [19]	Iran	1967–2003	JML, VECM	Real GDP, Natural Gas Consumption	Yes	$G\leftrightarrow Y$
Sari et al. [22]	US	2001–2005	ARDL, VECM	Industrial Production, Natural Gas Consumption	Yes	$G\leftarrow Y$
Hu and Lin [21]	Taiwan	1982–2006	Hansen and Seo [29], VECM	Real GDP, Natural Gas Consumption	Yes	$G\leftrightarrow Y$
Reynolds and Kolodziej [23]	Soviet Union	1928–2003	GC	Real GNP, Natural Gas Consumption	N. A	$G\rightarrow Y$
Adeniran [24]	Nigeria	1980–2006	GC by Sims [30]	Rea GDP, Natural Gas Consumption	Yes	$G\leftarrow Y$
Amadeh et al. [20]	Iran	1973–2003	ARDL, VECM	Real GDP, Natural Gas Consumption	Yes	$G\leftarrow Y$
Khan and Ahmad [8]	Pakistan	1972–2007	GC	Real GDP, Natural Gas Consumption	Yes	$G\rightarrow Y$
Clement [25]	Nigeria	1970–2005	JML, VECM	Real GDP, Natural Gas Consumption	Yes	$G\rightarrow Y$
Multi-Country Studies						
Yu and Choi [14]	UK	N. A	GC by Sims [30]	Real GNP, Natural Gas Consumption	N. A	$G\leftarrow Y$
	US				N. A	$Y\times G$
	Poland				N. A	$Y\times G$
Fatai et al. [16]	New Zealand	1960–1999	ARDL, JML, TY	Real GDP, Natural Gas Consumption	No	$Y\times G$
	Australia				Yes	$Y\times G$
Zahid [7]	Pakistan	1971–2003	TY	Real GDP per Capita, Gas Consumption	Yes	$Y\times G$
	Bangladesh				No	$G\rightarrow Y$
	India				No	$Y\times G$
	Nepal				No	$Y\times G$
	Sri Lanka				No	$Y\times G$
Apergis and Payne [1]	67 Countries	1992–2005	Pedroni [31,32] panel cointegration, GC	Real GDP, Natural Gas Consumption, Labor, Capital	Yes	$G\leftrightarrow Y$
Kum et al. [26]	Canada	1970–2008	Bootstrapping GC	Real GDP, Natural Gas Consumption, Capital	N. A	$Y\times G$
	France				N. A	$G\leftrightarrow Y$
	Germany				N. A	$G\leftrightarrow Y$
	Italy				N. A	$G\rightarrow Y$
	Japan				N. A	$Y\times G$
	United Kingdom				N. A	$G\leftarrow Y$
	United States				N. A	$G\leftrightarrow Y$

Notes: Y and G represent economic growth and natural gas consumption, respectively. $Y\rightarrow G$ indicates a unidirectional causality running from economic growth to natural gas consumption; $G\rightarrow Y$ indicates a unidirectional causality running from natural gas consumption to economic growth. $G\leftrightarrow Y$ indicates bidirectional causality and $Y\times G$ indicates no causal relationship. N. A means not applicable. GC, GFEVD, JML, WE, VECM, ARDL and TY means Granger causality, Generalized forecast error variance decomposition, Johansen's maximum likelihood, Weak exogeneity test, Vector error correction method, Autoregressive distributed lag model to cointegration and Toda and Yamamoto [33] causality test, respectively.

long-run equilibrium among the series. The ARDL bounds testing approach has several advantages. It yields consistent long-run estimators even when the right hand side variables are endogenous (Inder [42]). By using the appropriate order, it is possible to simultaneously correct the serial correlation in residuals and the problem of endogenous regressors (Pesaran and Shin [43]). This approach is applied irrespective of whether the variables are $I(0)$ or $I(1)$, unlike other widely used cointegration techniques. Moreover, a dynamic unrestricted error correction model (UECM) can be derived through a simple linear transformation. The UECM integrates the short-run dynamics with the long-run equilibrium without losing any long-run information. The UECM is specified as follows:

$$\begin{aligned}\Delta \ln Y_t = {} & \alpha_1+\alpha_T T+\alpha_Y \ln Y_{t-1}+\alpha_{GC}\ln GC_{t-1} \\ & +\alpha_K \ln K_{t-1}+\alpha_{EM}\ln EM_{t-1}+\alpha_{EXP}\ln EXP_{t-1}+\sum_{i=1}^{p}\alpha_i \Delta \ln Y_{t-i} \\ & +\sum_{j=0}^{q}\alpha_j \Delta \ln GC_{t-j}+\sum_{k=0}^{r}\alpha_k \Delta \ln K_{t-k}+\sum_{l=0}^{s}\alpha_l \Delta \ln EM_{t-l} \\ & +\sum_{m=0}^{t}\alpha_m \Delta \ln EXP_{t-m}+\mu_t \qquad (3)\end{aligned}$$

Table 2
Results of unit root tests.

Variables	ADF	PP	DF-GLS
$\ln Y_t$	−1.4110(1)	−1.4907(1)	−1.4571(0)
$\Delta \ln Y_t$	−4.3214(0)***	−4.4607(3)***	−4.4120(1)***
$\ln GC_t$	−1.9204(1)	−2.6838(3)	−1.7627(1)
$\Delta \ln GC_t$	−4.4369(1)***	−8.2059(3)**	−4.6660(1)***
$\ln K_t$	−1.6737(1)	−1.5122(3)	−1.8960(1)
$\Delta \ln K_t$	−3.9841(0)**	−4.0145(3)**	−3.0766(0)*
$\ln EM_t$	−2.5090 (1)	−3.1495 (1)	−1.7402 (1)
$\Delta \ln EM_t$	−5.0983 (1)***	−5.2274 (1)**	−10.7988 (3)***
$\ln EXP_t$	−2.5842(1)	−2.7970(3)	−2.3730(1)
$\Delta \ln EXP_t$	−4.8699(1)***	−6.3962(3)***	−4.9912(1)***

Note: ***, ** and * denote the significance at 1%, 5% and 10% levels, respectively. Figure in the parenthesis is the optimal lag structure for ADF and DF-GLS tests, and bandwidth for the PP test.

where Δ is the first difference operator, T is the time trend and μ_t is the error term. The optimal lag structure of the first difference regression is selected based on Akaike Information Criteria (AIC). The lags is induced when noise in the error term. Pesaran et al. [41] suggested F-test for joint significance of the coefficients

of the lagged level of the variables. For example, the null hypothesis of no long-run relationship between the variables in Eq. (3) is H_0:$\alpha_Y=\alpha_{GC}=\alpha_K=\alpha_{EM}=\alpha_{EXP}=0$ against the alternative hypothesis of cointegration H_1:$\alpha_Y \neq \alpha_{GC} \neq \alpha_K \neq \alpha_{EM} \neq \alpha_{EXP} \neq 0$.

Two asymptotic critical bounds are used to test for cointegration. If the order of integration for all series is one, the decision is made based on the upper bound. Similarly, if all series are $I(0)$, then the decision is based on the lower bound. If the F-statistic exceeds the upper critical value, we conclude the favor of long run relationship. If the F-statistic falls below the lower critical value, we cannot reject the null hypothesis of no cointegration. However, if the F-statistic lies between the two bounds, inference is inconclusive.

3.2. Innovative accounting approach for granger causality

The Granger causality test does not determine the relative strength of causality effect beyond the selected time span (Wolde-Rufael [44]). It is unable to indicate how much feedback exists from one variable to the other. To overcome the shortcoming of Granger causality test, we employ Innovative Accounting Approach (IAA) to investigate the dynamic causality relationships among economic growth, natural gas consumption, capital, labor and exports. IAA avoids the problem of endogeneity and integration of the series. This approach is superior to the VECM Granger causality test because the latter only shows causal relationship between the variables within the sample period while the former illustrates the extent of causal relationship ahead the selected sample period.

The IAA includes forecast error variance decomposition and impulse response function. The forecast error variance decomposition method explains the proportion of movements in the series due to its own shocks as well as shocks stemming in other variables (Enders [45]). A system of equations is used to examine the impact of one standard deviation shock stemming in the variable on the other variables as well as on the future of the shocked series (Shan [46]). This procedure decomposes forecast error variance for each series following a standard deviation shock to a specific variable and enables us to test which series is strongly impacted and vice versa.

For instance, if a shock in economic growth has significant effect on the changes in natural gas consumption but a shock occurring in natural gas consumption only affect very minimum the variations of economic growth. Then, this is inferred as a unidirectional causality from economic growth to natural gas consumption. If the natural gas consumption explains more of the forecast error variance of economic growth; then we deduce that natural gas consumption causes economic growth. The bidirectional causality exists when shocks in economic growth and natural gas consumption have strong impact on the variations of natural gas consumption and economic growth, respectively. If shocks occur in both series do not have any impact on the changes in natural gas consumption and economic growth then there is no causality between the variables.

Impulse response function helps us to trace out the time path of impacts of shocks of variables in the VAR. One can determine how much economic growth responses due to its own shock and shock in natural gas consumption. We support the hypothesis that economic growth causes natural gas consumption if the impulse response function indicates significant response of natural gas consumption to shocks in economic growth than other variables. A strong and significant reaction of economic growth to shocks in natural gas consumption implies that natural gas consumption causes economic growth.

This study incorporates capital, labor and exports to examine the relationship between natural gas consumption and economic growth in the VAR model. A VAR system takes the following form (Shan [46]):

$$V_t = \sum_{i=1}^{k} \delta_i V_{t-i} + \eta_t \tag{4}$$

Table 3
The ARDL cointegration analysis.

Bounds testing to cointegration		
Estimated equation	*Yt=f(GCt,Kt,EMt,EXPt)*	
Optimal lag structure	(1, 1, 1, 1, 0)	
F-statistics	8.2044**	
Significant level	Critical values (T=38)[a]	
	Lower bounds, $I(0)$	Upper bounds, $I(1)$
1%	10.265	11.295
5%	7.210	8.055
10%	5.950	6.680
Diagnostic tests	Statistics	
R^2	0.7522	
Adjusted-R^2	0.5789	
F-statistics	4.3386(0.0015)	
Durbin–Watson test	1.9659	
χ^2 *NORMAL*	2.5663 (0.2771)	
χ^2 *SERIAL*	0.2542 (0.7782)	
χ^2 *ARCH*	0.0226 (0.8814)	
χ^2 *WHITE*	0.4436 (0.9381)	
χ^2 *RAMSEY*	1.2663 (0.2745)	

Note: χ^2 *NORM*is for normality test, χ^2 *SERIAL*for LM serial correlation test, χ^2 *ARCH* for autoregressive conditional heteroskedasticity, χ^2 *WHITE*for white heteroskedasticity and χ^2 *REMSAY* for Resay reset test.

** denote the significance at 5% level. Probability values are given in the parenthesis.

[a] Critical values from Narayan [48].

Table 4
Results of johansen cointegration test.

Hypothesis	Trace statistic	Maximum eigen value
R=0	125.1119***	75.4751***
R≤1	49.6367**	27.8837**
R≤2	21.7530	12.1759
R≤3	9.5770	9.5617
R≤4	0.0153	0.0153

Note: *** and ** show significant at 1% and 5% level, respectively.

Table 5
Long run results.

Dependent variable=$\ln Y_t$			
Variable	Coefficient	T-statistic	Prob. value
Constant	−33.2849	−1.7595*	0.0880
$\ln GC_t$	0.4115	8.1183***	0.0000
$\ln K_t$	0.3548	6.4961***	0.0000
$\ln EM_t$	0.0941	2.2634**	0.0305
$\ln EXP_t$	0.0852	1.7421*	0.0911
Diagnostic test			
R-squared		0.9889	
Adjusted R-squared		0.9875	
F-statistics		715.0525***	
Durbin–Watson		1.5385	
χ^2*NORMAL*		4.0093 (0.1347)	
χ^2*SERIAL*		0.8270 (0.4471)	
χ^2*ARCH*		0.7453 (0.4826)	
χ^2*WHITE*		0.4461 (0.7744)	
χ^2*RAMSEY*		0.9047 (0.3489)	

Note: ***, ** and * indicates significance at 1%, 5% and 10% levels. Prob-values are shown in parentheses

Table 6
Short run results.

Dependent variable = $\Delta \ln Y_t$			
Variable	Coefficient	*T*-statistic	Prob. value
Constant	0.0181	6.5014***	0.0000
$\Delta \ln GC_t$	0.1130	3.8072***	0.0006
$\Delta \ln K_t$	0.0609	1.9258*	0.0636
$\Delta \ln EM_t$	0.0483	0.2940	0.7707
$\Delta \ln EXP_t$	0.0531	2.7816***	0.0093
ECM_{t-1}	−0.4333	−7.8261***	0.0000
Diagnostic test			
R-squared		0.4914	
Adjusted *R*-squared		0.4066	
F-statistics		5.7657***	
Durbin–Watson		1.8495	
χ^2 *NORMAL*		0.9260 (0.6293)	
χ^2 *SERIAL*		0.1328 (0.8761)	
χ^2 *ARCH*		1.9565 (0.1584)	
χ^2 *WHITE*		1.6425 (0.1792)	
χ^2 *RAMSEY*		0.4426 (0.5111)	

Note: *** (*) indicates significance at 1% (10%) and prob-values are shown in parentheses.

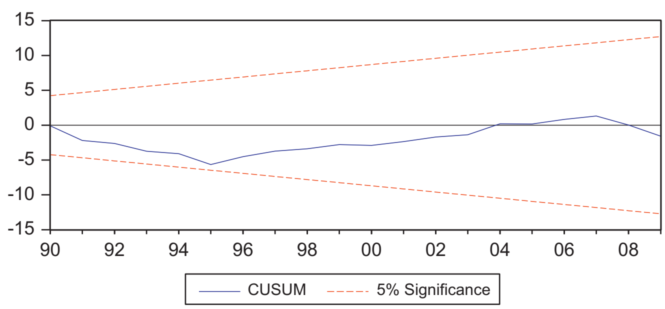

Fig. 1. Plot of cumulative sum of recursive residuals.
Note: The straight lines represent critical bounds at 5% significance level.

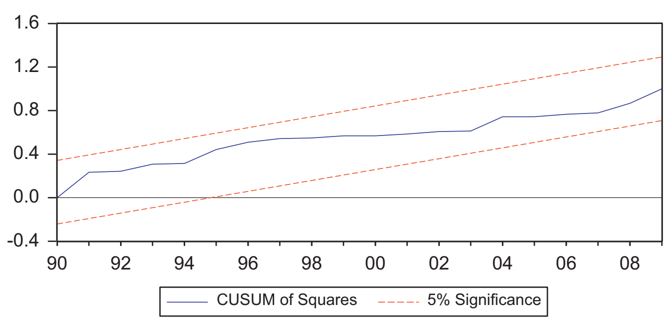

Fig. 2. Plot of cumulative sum of squares of recursive residuals.
Note: The straight lines represent critical bounds at 5% significance level.

where, $V_t = (Y_t, GC_t, K_t, EM_t, EXP_t)$, $\eta_t = (\eta_Y, \eta_{GC}, \eta_K, \eta_{EM}, \eta_{EXP})$ δ_I are the estimated coefficients and η is a vector of error terms.

4. Empirical results

ADF, PP and DG-GLS unit root tests are applied to investigate the order of integration and results are reported in Table 2. We find that all variables are $I(1)$.

Selection of appropriate lag length is necessary for the ARDL bounds test because the calculation of *F*-statistic is sensitive to the lag order. The appropriate lag length of *1* is selected based on AIC[3]. Lütkepohl [47] pointed out that AIC is superior for small sample. Result of the ARDL bounds test in Table 3 suggests that the null hypothesis of no cointegration is rejected at 5% level of significance.

We also perform the Johansen and Juselius [49] cointegration test to check the robustness of long-run relationship. Results in Table 4 confirm that the long-run relationship between the variables is valid and robust.

Table 5 reports the long-run elasticity of each production factors and reveals that natural gas consumption is significantly positive related to economic growth. This finding is consistent with Apergis and Payne [1] in the case of 67 economies including Pakistan but contradict with Işik [50] for Turkey[4] . The result posits that a 1% rise in natural gas consumption is linked with 0.4% rise in economic growth. An increase in capital is linked positively with real GDP and significant at 1% significance level. This empirical evidence is consistent with Arby and Batool [51] that capital also plays its role in sustaining economic development. It is reported that 0.4% of economic growth rises from a 1% rise in capital use. Economic growth is also positively and significantly affected by labor. Saten and Shahbaz [52] and Shahbaz and Dube [53] reported that employment is also

Table 7
Variance decomposition.

Period	$\ln Y_t$	$\ln GC_t$	$\ln K_t$	$\ln EM_t$	$\ln EXP_t$
$\ln Y_t$					
1	100.0000	0.0000	0.0000	0.0000	0.0000
3	76.4935	21.2781	1.0810	1.0188	0.1284
5	57.0170	38.5178	2.1440	2.0616	0.2593
7	40.4757	47.6085	9.1494	1.9994	0.7668
8	34.0623	49.1439	14.0426	1.6890	1.0620
9	28.9344	49.2080	19.1050	1.3998	1.3526
10	24.9474	48.3156	23.9014	1.2300	1.6053
$\ln GC_t$					
1	19.6528	80.3471	0.0000	0.0000	0.0000
3	13.8222	63.9539	20.0026	1.8770	0.3441
5	8.7610	52.7844	35.9414	1.5771	0.9358
7	6.6254	46.5851	43.4580	1.8069	1.5244
8	6.0424	44.5294	45.5676	2.1497	1.7106
9	5.6341	42.8695	47.0102	2.6751	1.8109
10	5.3534	41.6297	48.0302	3.1165	1.8700
$\ln K_t$					
1	6.2666	1.07615	92.3098	0.0000	0.3473
3	13.1346	1.24892	83.2431	2.0518	0.3214
5	15.8241	10.5559	67.8920	5.4739	0.2539
7	14.4267	19.6999	58.4891	7.0035	0.3807
8	13.2716	22.1760	57.2544	6.7255	0.5722
9	12.3040	23.3354	57.2955	6.2540	0.8108
10	11.6144	23.5498	57.9014	5.8950	1.0391
$\ln EM_t$					
1	2.6015	3.2993	2.9403	78.5495	12.6091
3	2.9132	11.3226	6.7331	66.2350	12.7958
5	2.6156	17.5243	7.5132	59.6332	12.7135
7	2.9107	20.5586	10.3620	54.0385	12.1299
8	3.4556	20.2531	13.5919	51.0387	11.6604
9	4.0911	19.4521	16.5762	48.6632	11.2172
10	4.7487	18.6371	18.7042	47.0570	10.8527
$\ln EXP_t$					
1	17.4163	12.7387	0.0000	0.0000	69.8448
3	26.6330	14.3588	5.2155	8.5205	45.2720
5	25.2609	17.0823	14.1449	9.4345	34.0772
7	24.5110	21.0905	15.2674	8.7113	30.4196
8	23.9437	23.1116	15.6043	8.2700	29.0703
9	23.1386	25.1329	16.1785	7.8250	27.7247
10	22.1875	26.8111	17.2129	7.3973	26.3909

[3] These results are available upon request from the authors.

[4] Işik [50] used bivariate model to examine the impact of natural gas consumption on economic growth in Turkey.

responsible to enhance economic growth in Pakistan. A 1% increase in employment will cause 0.1% increase in real GDP. Our result also validates the export-led growth hypothesis in Pakistan. A one percent increase in exports will boost economic growth by 0.1%. This finding is consistent with Shahbaz et al. [57] and latter on Shahbaz [58].

Table 6 reports the short-run results. It is found that natural gas consumption has a positive and significant impact on economic growth. A rise in capital boosts economic growth and similar inference could also be drawn for exports but effect of employment is insignificant. The lagged error term i.e., ECM_{t-1} is having the expected negative sign and statistically significant at 1% level of significance. This confirms the existence of long-run relationship among the variables. The coefficient of lagged error term implies that deviations from short run to the long-run equilibrium in the current to future period are corrected by about 43.33% per year.

The diagnostic tests confirm that error term is normally distributed, autoregressive conditional heteroscedasticity is not found and there is no serial correlation in the model. The Ramsey RESET test shows that the functional form of the model is well specified. Furthermore, the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) of recursive residuals reveal that our selected ARDL model is stable (see Figs. 1 and 2).

The variance decomposition explains how much of the predicted error variance of a variable is described by innovations generated from each independent variable in a system over various time horizons. The results reported in Table 7 indicate that economic growth is explained strongly by natural gas consumption and capital, respectively while the contribution of exports and labor is small. For natural gas consumption, the contribution of capital is increasing overtime and explains 48% of its predicted error variance at period-10. The contribution of economic growth, labor, and exports to natural gas consumption, respectively is negligible. Overall, we find unidirectional causality from natural gas consumption and capital to economic growth; and from natural gas consumption to exports. Bidirectional causality is found between natural gas consumption and capital.

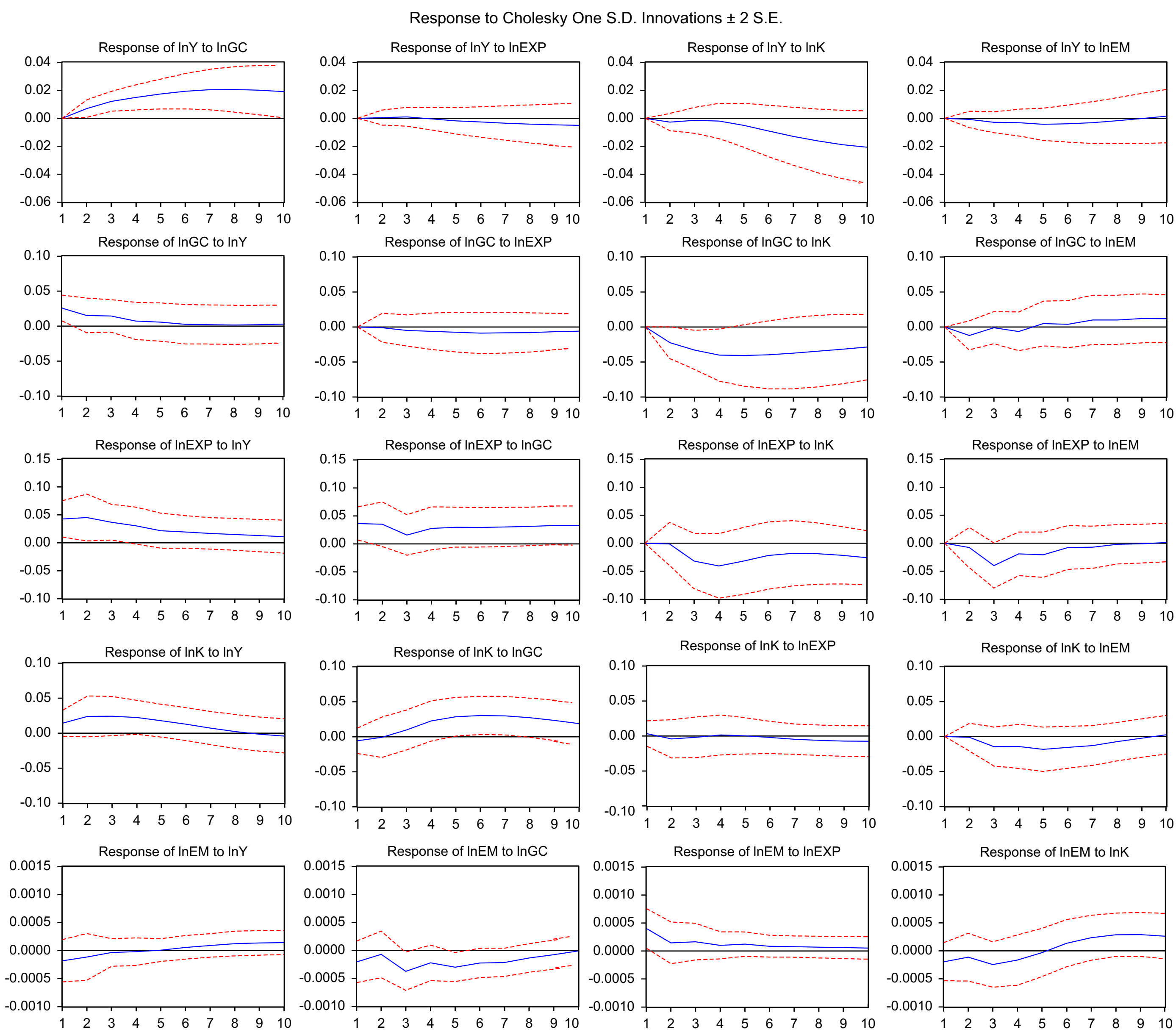

Fig. 3. Impulse response function.

The impulse response function indicates how long and to what extent dependent variable reacts to shock in forcing variables. The results in Fig. 3 show positive response of economic growth due to one standard deviation shock in natural gas consumption for 10 time horizons. However, the economic growth responds negatively to shock in capital, labor and exports. The response of natural gas consumption to shock in economic growth is positive but is decreasing and dies out after the 6th time horizon. Natural gas consumption responds negatively to shock in capital and exports but the response change from negative to positive in labor after the 6th time horizon. Hence, we support that natural gas consumption causes economic growth but not vice versa.

5. Conclusions

This study investigates the relationship between natural gas consumption and economic growth by incorporating real capital, labor and real exports in a multivariate framework in case of Pakistan. The ARDL bound testing approach shows the existence of long-run relationship among the variables. Natural gas consumption, capital, labor and exports positively affect economic growth. Furthermore, we support natural gas consumption-led-growth hypothesis. This suggests that natural gas conservation policies may retard economic growth.

With gas being a primary energy source accounting for 48% of the total energy in 2008, Pakistan needs to ensure that this source of energy is able to meet the growing demand. The appropriate policy on natural gas should be tailored to improve the energy efficiency that consistent with the pace of economic growth. Being one of the largest users of condenses natural gas; Pakistan should increase the investment in gas production's infrastructure and technology development. In addition, intensify the private-public partnership would ensure a more reliable supply of gas, operational efficiency and better distribution. The commitment of increasing local gas exploration and investment attraction and incentives in gas production would ensure sustainable supply of gas to propel the economy. This would also ensure the local gas price is kept at an affordable rate.

Furthermore, Pakistan has the fourth largest coal reserves in the world. Adoption of advanced technology to convert coal into green gas can be considered as an alternate source of gas consumption. Although the government started solar electricity in some areas, we suggest that the government also need to expand the bio-energy network to villages and train the people through environmental awareness programs. Moreover, government may also launch micro-financing scheme for bio-energy production.

Future study may look at the provincial level to investigate the relationship between natural gas consumption and economic growth. Sectoral analysis also can be conducted in key sectors such as agriculture, industrial and services. This may help the policy makers to formulating a comprehensive energy policy for sustainable economic growth at provincial as well as sectoral levels.

To meet the growing demand of energy, we must ensure the efficiency and renewable of energy sources. Renewable energy provides the most appropriate energy infrastructure that meets the demand of the current generation without compromising the availability of future generations to meet their energy needs (Omer [54]). Renewable energy gives a path to sustainable development (Çoban and Yorgancılar [55]). Technologies that promote sustainable energy include renewable energy sources, such as hydroelectricity, solar energy, wind energy, wave power, geothermal energy and tidal power. In developing countries like Pakistan, although crude oil and natural gas will remain as predominant sources of energy for the near future. It is foreseen that the development of renewable energy will ensure the sustainable and secure future.

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